Social Networking 2.0

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Abstract
In this paper we describe the development of a platform that enables us to systematically study online social networks alongside their real-world counterparts. Our system, entitled Cityware, merges users' online social data, made available through Facebook, with mobility traces captured via Bluetooth scanning. Furthermore, our system is constantly growing, since it enables users to contribute their own mobility traces. In addition to describing Cityware's architecture, we discuss the type of data we are collecting, and the analyses we intend to carry out.

Keywords
Social networks, bluetooth, Facebook, mobile phones.

ACM Classification Keywords
H5.m. Information interfaces and presentation: Miscellaneous.

Introduction
The recent proliferation of online social networking system such as Facebook, Dodgeball and MySpace, has provided researchers with platforms for carrying out research into online social behaviour. Typically in the HCI domain such studies have looked at the effect of social incentives and contextual information on the use of public transportation [e.g. 1], the relationship

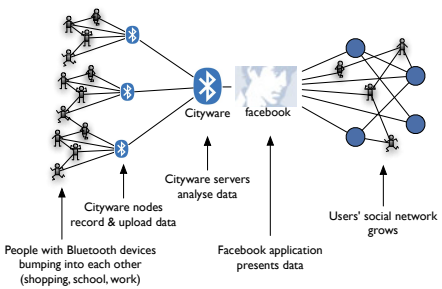

figure 1. Overview of the Cityware platform.

between users' online profiles and their online behaviour [e.g. 4], and the various trust issues that emerge from using such systems [e.g. 7]. In order to make inferences from online behaviour datasets, researchers still have to collect data from the real world and relate it to the online data. Thus, while social networking websites make it easy to capture large amounts of data, researchers still need to employ interviews, focus groups, questionnaires, or any other method that enables them to relate online with real world data.

In this paper we describe the development of the Cityware platform, which aims to bridge the gap between online and physical social networks. It allows users to explore an amalgamation of their online and physical social networks. The key strength of our platform is that it allows the collection of vast amounts of quantitative data, both from the online and real worlds, which is immediately linked, synchronised, and available for further analysis. Here we describe the architecture of our platform, the types of data it makes available to users and researchers, the typical user-oriented scenarios that are beginning to emerge, and our planned research-oriented scenarios.

Cityware

Our platform can be described as a massively distributed system, spanning both the online and physical worlds. Its architecture uniquely allows it to expand and contract in real time, while also enabling live data analysis. The main components of the platform are: people's Bluetooth-enabled devices, Cityware nodes, Cityware servers, Facebook servers, and a Facebook application. An overview of this architecture is shown in Figure 1.

Unlike other systems [9,10] Cityware does not require any software to run on the phones and mobile devices. Thus, potentially any device with standard Bluetooth capability can take part in our system. Furthermore, while previous work has focused on injecting presence information in the physical space [11], our work is focused on providing an online representation of users' physical and online social networks.

Infrastructure

In many ways the most vital element of our platform is people's Bluetooth enabled mobile devices, such as mobile phones, PDAs or laptops. For any data to be collected, users must have switched on their Bluetooth devices, and set them to "discoverable" mode. From empirical observations, we know that, at least in certain cities in the UK, about 7.5% of observed pedestrians had Bluetooth switched on and set to discoverable [6]. More crucially, however, Bluetooth matches very closely to people's movement, as it typically has a short range (10 or 100 meters).

The presence of discoverable Bluetooth devices is captured via the deployment of Cityware nodes. These nodes are computers that carry out constant Bluetooth scanning, thus recording details about the Bluetooth devices in the immediate vicinity. Initially, we deployed a small number of nodes as part of a pilot study. However, we also released open-source software that allows users to turn their Windows, Linux, and OS X computers into nodes. Additionally, we modified the open-source application WirelessRope [5] to make it compatible with our platform, thus enabling mobile phones themselves to become Cityware nodes. So far, our platform has attracted hundreds of individuals

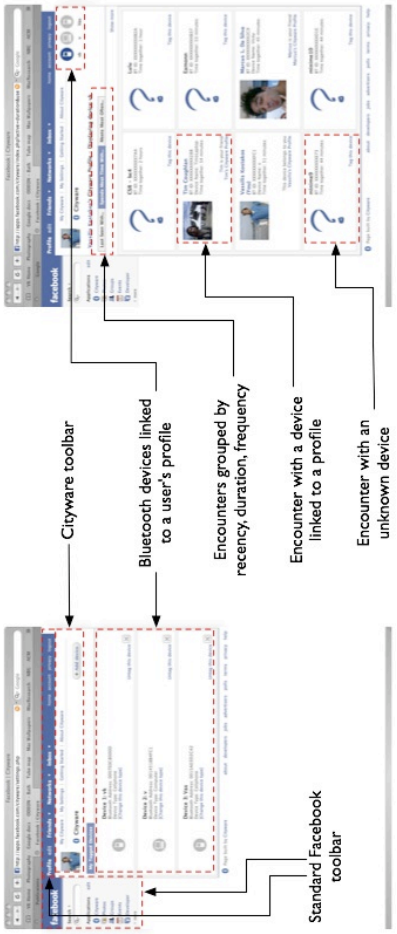

figure 2. Screenshots of the Cityware user interface.

worldwide who have set up their own nodes and are uploading data to our servers.

The Cityware servers are responsible for analysing the data arriving from the nodes. This analysis takes place in two stages [3]. First the incoming raw data is transformed into what we call "sessions". Due to the technical properties of the Bluetooth enquiry performed by Cityware nodes, the data arriving at the server describe discrete points in time in which a specific device was seen. The process of transforming such data to "sessions" enables us to add the notion of duration to such events, thus more closely describing people's visits near a particular node. The second step of our analysis looks for "encounters" between individuals. This is achieved by identifying overlapping sessions that were recorded by the same node. In other words, encounters are instances when two devices where are the same place at the same time.

User interface

Our platform relies on the Facebook system (http://www.facebok.com) in order to present data to users. Our user interface has been deeply integrated with the Facebook system itself, matching its look and feel and using a number of Facebook's capabilities. A screenshot of our UI is shown in Figure 2.

To access our system, users must have a Facebook account, and additionally they must opt to add the Cityware application to their Facebook profile. The next step in using our application is for users to register their devices. This involves typing into our system the Bluetooth identifier of their device. Users may associate more than one Bluetooth device with their Facebook profile.

Once this link has been established between Bluetooth data and a users' Facebook profile, our system is able to display the user's encounters, sorted either by recency, duration, or frequency. Thus, users are able to explore who they met most recently, who the spend most time with, and who they meet most frequently. For each encounter, our system displays the Bluetooth name of the device (as recorded by the Cityware nodes). If a user recognises a device as belonging to someone they know, they are able to "tag" that device, thus linking it to a Facebook account and to that account's owner. If this happens, the owner of the newly tagged device is notified via the built-it Facebook mechanisms.

The end result is that users are presented with a list of encounters that have taken place in the real world, with some of those encountered devices being linked to Facebook profiles. For such devices our system can display the owner's picture as a well as a link to that person's profile.

Our platform's distinctive characteristic is that it provides information that both end-users and researchers can use. This is because end-users see and explore data that is directly related to them (i.e. who they meet, and related statistics), while researchers have access to the "big-picture", thus being able to explore and understand aggregate behaviour. Additionally, the self-registration and tagging mechanisms provide the crucial links between online and real-world networks. Effectively, our system enables users to annotate our dataset, thus enriching it with all the information that users make available via their Facebook profiles.

User feedback

Facebook has built-in discussion board mechanisms to facilitate public and private conversations. This has proven to be an invaluable mechanism for collecting and categorising user feedback. A community has begun to form around our platform, with members using the discussion board to help other users with technical difficulties, suggesting design ideas, and holding debates.

Prominent amongst the discussion topics is troubleshooting. Many users have posted questions in relation to the node software installation, making sure software runs constantly, how bluetooth works, as well as how Cityware works. Fellow users have responded to these queries, suggesting that a self-helping community is being formed around Cityware.

While Cityware was officially release in late July 2007, it was not until mid-August that it became widely popular, mostly due to a report by the BBC [8]. Since then, we have observed a quite interesting phenomenon amongst users of Cityware. As if feeling somehow "connected" or part of the same social group, our users are eager in establishing new nodes all over the world. A big part of the online discussion evolves around users proudly stating that they have established "yet another node", thus making their town or city part of Cityware. Additionally, users are eagerly posting messages requesting to know if there are any nodes near where they live.

A further interesting aspect of the feedback we have collected has to do with the context in which users are setting up nodes. While some users have reported establishing nodes in their homes, others have done so in their workplaces. Furthermore, some users of our application own shops and establishments (such as nighclubs) in which they have installed Cityware nodes. A feature that was heavily requested by users was the use of a map to visually locate Cityware nodes. Since we had not developed such functionality, we instructed users to mark their nodes on the public website http://www.wikimapia.com. This enables users all over the world to locate, as well as mark, Cityware nodes, post comments about them, or even attach pictures.

Last but not least, privacy is a much-debated topic amongst users of Cityware. While some users are being critical of Cityware's privacy implications, many are supportive. We should note that the discussion board is not public, but rather only for self-selected users of Cityware, and as such may not be representative of the general public. Certain users have expressed concern about people being tracked about a city, and having their preferences and routines being inferred by a malicious party. In response, other users commented that anyone can at any time opt-out of Cityware by switching Bluetooth to "invisible". Additionally, it was highlighted that authorities can track people who simply own a mobile phone, regardless of Cityware. Furthermore, users commented that location is not being made available by our system, but nevertheless could be inferred. Another user noted that people are already disclosing information about themselves via their Facebook profile, and that Cityware can expose only that information. A good synopsis was offered by a user who wrote: "There are two groups of people here - one group that willingly submits to this, and the other group, that are totally opposed to any tracking/recording."

Research potential

While end users of Cityware are enjoying the functionality of our system, we are quite interested in the research possibilities that our platform has enabled. To quickly summarise some properties of our system at the time of writing: 3000 people have added Cityware to their Facebook profile, 450 nodes have been registered, while roughly 100,000 unique Bluetooth devices have been recorded by all Cityware nodes.

The dataset being collected by Cityware nodes is extremely rich as it describes people's visiting and encounter patterns across space and time. While comparable datasets, such as the Crawdad project [2], are available to the scientific community, it is only when such quantitative data can be linked to qualitative data that interesting research possibilities open up. While Cityware collects large amounts of quantitative data on people's movement and encounters, it also has access to the extremely rich qualitative data that people make available through their Facebook profiles.

Typically, Facebook users provide a wealth information on their profile, including their demographics and preferences. More crucially, however, users annotate their relationships with people they know. Friends can be marked, for example, as colleagues, house-mates, or relatives. Additionally, a relationship can be annotated with dates, locations or organisations that may be relevant.

By combining the wealth of user-supplied qualitative data with the large amounts of quantitative data collected by Cityware nodes, we can begin to explore new research approaches to social metrics, system design, security, and even epidemiology.

The logical next step for our research would be to compare people's movement and encounters with the qualitative data provided by users. For example, we can begin to empirically understand how people spend their time: with friends, family, or colleagues? Do these patterns change over time, seasons, or countries? Additionally, we want to explore if "friendship", "house-mate", or any other type of relationship systematically manifests the same Bluetooth patterns. This would lead the way for developing systems that can automatically classify a user's social network into friends, colleagues, etc.

Another area to explore would be the use of such data to make predictions about the users' behaviour, and accordingly adapt any software they may be using. At the moment we have distributed node software that runs on mobile phones. This software could act upon predictions about user behaviour and adapt any of the phone's functionality. Crucially, user feedback about the validity of predictions can easily be related back to our servers for further analysis.

A further research strategy is to explore the usefulness of our system for enhancing the security and privacy of users. We can conceptualise our dataset as a world map of relationships between users, annotated by users. This map may be used to inform users of security-related decisions they face when entering a new context, such as a restaurant in a city they are visiting for the first time. Our servers can identify user comments about such a place, but more importantly assign weight to such comments based on the the user's "social proximity" to the comment authors.

Finally, the data collected by Cityware is an invaluable source for understanding how mobility and encounter patterns can help in the diffusion of ideas, innovations and viruses. This could be achieved by exploring aggregate diffusion patterns over time, and exploring how different types of information (e.g 1Kb vs 1Mb) or viruses (biological / digital) would spread through the network of encounters and people.

Conclusion and Ongoing work

In this paper we have described the Cityware platform, how users have reacted to it, and the potential for research strategies that it has enabled. As part of our ongoing work we are developing visualisations that both end users and researchers can utilise for better understanding the various patterns and properties of our dataset. We are also considering the development of software that will allow users to automatically geo-tag their data if they have a compatible GPS receiver. Furthermore, we are in the process of correlating aggregate encounter patterns with user-specified properties of those encounters. Finally we are examining the potential viral spread through users' encounters, and relating viral spread to user-specified qualitative data.

Acknowledgements

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